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REMARKS

ON A

PAMPHLET

Lately publiſhed by the

Rev. Mr. *MASKELYNE*,

Under the AUTHORITY of the

BOARD OF LONGITUDE.

By JOHN HARRISON.

THE SECOND EDITION.

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REMARKS,

ON A

PAMPHLET, &c.

A PUBLICATION having lately been made by the Rev. Mr. *Maskelyne* Aſtronomer Royal, under the Authority of the Board of Longitude, manifeſtly tending, by the Suppreſſion of ſome Facts and the Miſrepreſentation of others, to impreſs the World with an unjuſt Opinion of my Invention, and falſely aſſerting that my Watch did not at certain Periods therein mentioned keep Time with ſufficient Exactneſs to determine the Longitude within the Limits preſcribed by the Act of the 12th of Queen *Anne*; I think it incumbent upon me to ſubmit ſome Obſervations thereon to the impartial Publick; and the rather, becauſe the ſaid Pamphlet is rendered ſo confuſed by unneceſſary Repetitions, and voluminous Tables, that a Man muſt be pretty converſant in theſe Matters, to trace and combine the Facts, ſo as to check the Concluſions, which would conſequently be taken upon Truſt by the generality of Readers, unleſs publickly contradicted. As it will be my Endeavour ſo far to avoid the Uſe of all Terms of Art as to make the Subject generally intelligible, I flatter myſelf I ſhall not be thought impertinent for giving a ſhort Explanation (though quite unneceſſary to the far greater Part of my Readers) of what the Longitude is, and what the Service required of the Watch.

The Longitude of any Place is its Diſtance Eaſt or Weſt from any other given Place; and what we want is a Method of finding out at Sea, how far we are got to the Eaſtward or Weſtward of the place we failed from. The Application of a Time-Keeper to this Diſcovery is founded upon the following Principles: The Earth's Surface is divided into 360 equal Parts (by imaginary Lines drawn from North to South) which are called Degrees of Longitude; and it's daily Revolution Eaſtward round it's own Axis is performed in 24 Hours; conſequently in that Period, each of thoſe imaginary Lines or Degrees, becomes ſucceſſively oppoſite to the Sun (which makes the Noon or preciſe Middle of the Day at each of thoſe Degrees); and it muſt follow, that from the Time any one of thoſe Lines paſſes the Sun, till the next paſſes, muſt be juſt four Minutes, for 24 Hours being divided by 360 will give that Quantity; ſo that for every Degree of Longitude we ſail Weſtward, it will be Noon with us four Minutes the later, and for every Degree Eaſtward four Minutes the ſooner, and ſo in Proportion for any greater or leſs Quantity. Now, the exact Time of the Day at the Place where we are, can be aſcertained by well known and eaſy Obſervations of the Sun if viſible for a few Minutes at any Time from his being ten Degrees high 'till within an Hour of Noon, or from an Hour after Noon 'till he is only 10 Degrees high in the Afternoon; if therefore, at any Time when ſuch Obſervation is made, a Time-Keeper tells us at the ſame Moment what o'Clock it is at the Place we ſailed from, our Longitude is clearly diſcovered. To do this, it is not neceſſary that a Watch ſhould perform it's Revolutions preciſely in that Space of time which the Earth takes to perform her's; it is only required that it ſhould invariably perform it in *ſome known Time*, and then the conſtant Difference between the Length of the one Revolution and the other, will appear as ſo much daily gained or loſt by the Watch, which conſtant Gain or Loſs, is called *the Rate of its going*, and which being added to or deducted from the Time ſhewn by the Watch, will give the true Time, and conſequently the Difference of Longitude.

I ſhall now proceed to make ſuch Remarks as occur to me on Peruſal of Mr. *Maskelyne*'s Pamphlet.

Mr. *Maskelyne* begins by telling us that the Board of Longitude, at their Meeting, *April*

26, 1766, came to a Reſolution that my Watch ſhould be tried at the Royal Obſervatory under his Inſpection, and that he accordingly received it on the 5th of *May*, 1766. He then ſays, "I moſt Days wound "up and compared the Watch with the "tranſit Clock of the Royal Obſervatory "myſelf; at other times it was performed "by my Aſſiſtant *Joſeph Dymond*, and after- "wards *William Baily*; this was always done "in the Preſence of, and atteſted by one of "the Officers of *Greenwich* Hoſpital, when "he came to aſſiſt in unlocking the "Box in which the Watch is kept, in "order to its being wound up."

Not one of thoſe Atteſtations appears in the Book: Perhaps Mr. *Maskelyne* thinks his Aſſertion of the Fact will be ſufficient for the Publick, and indeed ſo it might have been to me, had I not received different Information: But the Truth is, the Commiſſioners appointed a Set of Gentlemen to attend by Rotation the winding up of the Watch; they were to unlock the Box the Watch was in, to ſee it wound up and compared with the Clock, then to lock the Box again and take the Key with them, and Mr. *Maskelyne* was to have another Key, there being two Locks to the Box:* The Officers of *Greenwich* Hoſpital were appointed for this Service, ſome of whom from the Infirmities of Age, and Misfortunes in the Service, were ſcarce able to get up the Hill to the Obſervatory, ſo that when they came there, as can be proved from undoubted Eye Witneſſes, they only unlocked the Box, ſate down 'till Mr. *Maskelyne* had done what he thought proper, and then locked the Box again, and departed: and whatever Atteſtation they may be ſuppoſed to have made, I can prove that at ſeveral Times when Gentlemen of my Acquaintance happened to be preſent, the Attendance of the Officers was by no Means an effectual Check upon the Compariſon of the Watch with the Clock. I would not be thought to accuſe thoſe Gentlemen of Neglect of the Duty impoſed upon them; on the contrary I applaud their Diligence in being ready at all Hours of the Day to attend when Mr. *Maſkelyne* was pleaſed to appoint; and therefore I will even for the preſent (though contrary to Fact) ſuppoſe they have been the Check propoſed by the Commiſſioners of Longitude againſt any unfair Acceſs *to the Watch*, ſtill *the Clock* with which it was compared *was left entirely in* Mr. Maſkelyne*'s Power*, and an Alteration of the one could not but produce juſt the ſame Effect as an Error of the other, nor is there even the leaſt *Pretence of a Check* either on the Clock, or on its Compariſon with Obſervations of the Sun; nay on the contrary, Mr. *Maskelyne* did at this Time take the Key of the Clock from Mr. *Dymond* in whoſe Cuſtody it uſed to be, and kept it himſelf.

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* It may not perhaps be improper here to obſerve, that the Locks were ſuch as might be picked with a crooked Nail, that the Lock of which the Officers had the Key was on the 10th of *July* out of Order, and that Mr. *Maſkelyne* was ſorry this ſhould ever come to the Ear of the Publick.

Mr. *Maskelyne* then proceeds to give us an Account of the Watch's going from Day to Day, which in his 15th Page he concludes thus: " From the foregoing Num-
" bers it appears, that the Watch was get-
" ting from the very firſt near 20 ſeconds
" per day; a circumſtance which is not
" my buſineſs to account for; but which,
" as it kept near mean Time in the Voyage
" to Barbadoes, ſeems to ſhew that the
" Watch cannot be taken to pieces and put
" together again without altering its Rate
" of going conſiderably, contrary to Mr.
" *Harriſon*'s Aſſertions formerly."

When I made the Diſcovery, upon Oath, of the Principles and Conſtruction of the Watch, to ſix Gentlemen appointed by the Board of Longitude and to Mr. *Maſkelyne*, (who inſiſted on having a Right to attend, as being a Commiſſioner) which Diſcovery was finiſhed on the 22d Day of *Auguſt*, 1765, as appears by the annex'd Certificate,* the

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* " We whoſe Names are hereunto ſubſcribed do
" certify, that Mr. *John Harriſon* has taken his Time-
" Keeper to Pieces in the Preſence of us, and explain-
" ed the Principles and Conſtruction thereof, and eve-
" ry Thing relative thereto, to our entire Satisfaction;
" and that he alſo did to our Satisfaction anſwer to
" every Queſtion propoſed by us or any of us relative
" thereto; And that we have compared the Drawings
" of the ſame with the Parts, and do find that they per-
" fectly correſpond."

Nevil Maſkelyne,
John Michell,
William Ludlam,
John Bird,
Auguſt 22, 1765. *Thomas Mudge,*
William Matthews,
Larcum Kendall.

Watch then remained in my Hands, all taken to pieces: I little imagined the Board of Longitude would take it from me, as not conceiving any Uſe they could make of it; and having beſides received Aſſurances from them, that they only wanted the formal Delivery of it, in compliance with the Terms of the new Law, without meaning to deprive me of the Uſe of it: I therefore went on making ſome experiments, and alter'd the Rate of its going, thereby to determine a Fact I wanted to be ſatisfied about. The Watch was under this Experiment the latter End of *October*, 1765, when upon receiving the Certificate for the Remainder of the firſt Moiety of my Reward, I was ordered to deliver it to the Board. My Son, attending with it, being aſked if it was then as fit as before to aſcertain the Longitude, reply'd in the Affirmative; for as I have before ſhewn, the *Rate of its going*, when once aſcertained, does not prevent its keeping the Longitude. He was not aſked the preſent Rate of its going, nor could he have anſwer'd with preciſion if he had, becauſe we had not had Notice ſufficient to determine that Point; but we did, at that Time, tell ſeveral of our Friends that it went about 18 or 19 Seconds a Day, *faſt*, and we have at ſeveral Times ſince (without ever dreaming that this was to become a Point of public Diſcuſſion) had Occaſion to mention the ſame Thing to ſeveral Members of Parliament, Commiſſioners of Longitude and other Gentlemen, inſomuch that we did not believe any body was uninformed of it, who at all attended to the Buſineſs of the Longitude.

This may ſerve to account for the Circumſtance which Mr. *Maskelyne* declares, *it was none of his Buſineſs to account for*, why the Watch was getting near 20 Seconds per Day; but as to *his Inference*, I muſt ſay it betrays the moſt abſolute Ignorance of Mechanics, and of this Machine in particular, in which it is obvious (and for this Fact I appeal to the Watchmakers who ſaw it taken to Pieces) that its going at the ſame Rate when put together again, as before, depends (if none of the Parts are alter'd) upon nothing more complicated *than putting a ſingle Screw into the ſame Place from whence it was taken.* Indeed this Paſſage, and the ignorant and puerile Remarks which Mr. *Maskelyne* has been ſuffer'd to prefix to my written Deſcription of the Watch (to the Diſgrace of this Country in thoſe foreign Tranſlations it has already undergone) bring ſtrongly to my Remembrance an Obſervation made by ſome of the Gentlemen preſent at the Diſcovery, " that they wonder'd at his Patience " in attending ſo long to a Subject he ſeem'd " ſo totally unacquainted with."

Mr. *Maskelyne* then proceeds to tell us of a Change that happen'd in the going of the Watch, and ſays, " this Change began in " the Beginning of *Auguſt*, on the few and " only hot Days we had laſt Summer, " which yet were not extreme, the Ther- " mometer within Doors having never riſen

“ above 73°. the Reſt of the Summer in “ general was remarkably cool and tempe- “ rate.” When I took this Watch to Pieces I informed Mr. *Maskelyne* and the other Gentlemen, that in trying any Experiments with it, in Reſpect to Heat and Cold, it would be proper that it ſhould be ſo fixed that, as far as could be, the Heat ſhould have an equal Influence on all Sides of it; and it is obvious that the Thermometer ought to have been kept in the ſame Box with it; but as this was not done, I apprehend the Effects of Heat mention'd above do not merit much Attention; and therefore ſhall only obſerve that the Watch was placed in a Box with a Glaſs in the Lid and another in one Side, in the Seat of a Window level with the loweſt Pane of the Window, and expoſed to the South Eaſt, whilſt the Thermometer, which was to aſcertain the Degree of Heat the Watch was expoſed to, was placed in a ſhady Part of the Room: Now 'tis obvious that while the Air ſurrounding the Thermometer might be very temperate, there might, if the Sun ſhone upon it, be a heat in the Box, ſuperior to what was ever felt in the open Air in any Part of the World; and perhaps greater than any human being could ſubſiſt in, and conſequently improper, or at leaſt unneceſſary for this experiment.

Mr. *Maſkelyne* next tells us of an irregularity which he ſays happened in cold Weather, and ſays, “ However, it ſeems in ge- “ neral that the Froſt muſt have been the

“ cauſe of theſe irregularities, as well as
“ of the Watch's going ſo much ſlower in
“ the Month of *January*, than it had gone
“ before.” Mr. *Maſkelyne* ought along with this, to have publiſhed what I told him when I explained it; that the Proviſion againſt the effects of Heat and Cold was not *in this Machine* extended to all Degrees; that I never had tryed it ſo low as the freezing Point, which according to the beſt Informations I have been able to procure is a Degree of Cold *that never did exiſt between the Decks of a Ship at Sea*, in any Climate yet explored by Mankind.

Mr. *Maſkelyne* then comes to the Rate of its going in different Poſitions; and ſays,
“ It is obvious, theſe laſt-mentioned Trials
“ of the Watch in a vertical Poſition could
“ not be deſigned to ſhew how near it would
“ go at Sea, where it can never obtain theſe
“ Poſitions: the Intent of them is to prove
“ how near Mr. *Harriſon*'s Execution of
“ his Watch comes up to his Principles,
“ with reſpect to the making all the Arcs
“ deſcribed by the balance, whether large
“ or ſmall, to be performed in the ſame
“ Time, as Mr. *Harriſon* aſſerts them to
“ be.” Mr. *Maskelyne* here alſo might have had Candour enough to inform the Public, as I did him, that although the Watch was quite ſufficient to anſwer the Purpoſes required of it in Navigation, and to fulfil what was preſcribed by the Act of Queen *Anne*, yet it was far from being in a ſtate of Perfection, *as an univerſal exact Time-Keeper*

for every Purpoſe: I ſhew'd him and the reſt of the Gentlemen the Reaſons why the Machine then before them, would not go at the ſame Rate in ſuch different Poſitions *into which the Motion of a Ship could never put it*; and whilſt I explained to them thoſe Imperfections in the particular Machine we were examining, I alſo in the cleareſt Manner I was able, pointed out the means of remedying them with certainty in others, which the Gentlemen ſkill'd in Mechanics ſeem'd perfectly to comprehend, and to be ſatiſfied of the Truth which I again aſſert, that Watches made on my Principles will endure a much greater Motion and change of Poſition than they can ever be ſubject to in a Ship; and that they will not be affected by any Degree of Heat or Cold, in which a Man can live.

If any Thing was meant to be concluded with reſpect to me by this Experiment, either in Point of Property or of Reputation, common Juſtice would have required that I ſhould have had an Opportunity of ſeeing the Facts aſcertained; and when ſuch a Trial was directed as put the Reſult in the abſolute Power of a ſingle Perſon, that I ſhould have been ſatisfied of his Integrity Diſintereſtedneſs and Ability for the purpoſe. I would not be underſtood to attack Mr. *Maskelyne*'s Knowledge of the Theory of Aſtronomy; as for any Thing I know to the contrary, it may be of the very firſt Rate, eſpecially as the Commiſſioners have thought proper to entruſt him with the Execution of their commands; and which he has ever been as ready to undertake: But alas! as to his ſkill in Mechanics, he knows little or nothing of the matter he has ventur'd to take in Hand.

I think it more conſiſtent with the reſpect I owe to the Public, and myſelf, to ſpeak out plainly, than to have recourſe to *Inſinuations*, on a Subject of this nature: I therefore declare, that I am not ſatisfied with the Truth of his reporting other Obſervations relative to the Longitude, as I do maintain that in both his Voyages the Obſervations which he ſaid he made the Land by, were not calculated till after he had ſeen the Land; and I am certain thoſe he has given, in the Publication now before us, are not genuine, for he pretends to find each Obſervation of the Tranſit of the Sun to the hundredth part of a Second of Time,—a Degree of exactneſs about twenty Times beyond what any other Obſerver has hitherto found practicable: Moreover I know him to be deeply intereſted in the Lunar Tables, a Scheme ſet up ſome Years ago for the Reward in Competition with my Invention, and for which large Sums of Money have already been paid by the Public.

Although I flatter myſelf the Reader is already in Poſſeſſion of very ſufficient Reaſons for rejecting the whole Pamphlet as partial and inconcluſive, yet I entreat his patient Attention whilſt I advance one ſtep farther, and ſhew, that although Mr. *Maskelyne* has preſented us with a ſet of Obſervations which *according to his mode of Calculation*, prove what he advances, yet thoſe very Obſervations when rightly reaſoned upon *prove the contrary*; and that in each of the Periods he refers to, except thoſe of the ſevere Froſt and improper Poſitions (againſt which Mr. *Maskelyne* ought to have informed the World I never warranted this particular Watch) it kept Time with ſufficient correctneſs to determine the Longitude within the limits of the Act of Queen *Anne*.

The Reader by this Time knows enough of the Subject to ſee, that in order to try whether the Watch would or would not keep Time with ſufficient Exactneſs to determine the Longitude, Mr. *Maskelyne*'s firſt Operation, after receiving it, ſhould have been to aſcertain *the Rate of its going*. But no ſuch Thing happened: he knew it had not gone exactly correſpondent to mean Time, during the Voyage to *Barbadoes*; it had been publickly enough declared that its Rate of going had been ſince altered; and, if he had not received that Information, he might nay muſt have diſcovered it in the firſt 24 Hours Tryal; however, without once attending to this *eſſential Circumſtance*, he goes to work, comparing the firſt Period of ſix Weeks (which he obſerves is generally reckoned the Term of a Weſt-India Voyage) when it was in an horizontal Poſition, with *mean Time*, inſtead of *the corrected Time*, and each ſucceeding Period with that immediately preceeding it! Who can heſitate in pronouncing that his Concluſions muſt be all erroneous? He ſhould firſt have aſcertained the Rate of its going by a Length of Obſervations of the Sun or Stars, or by a perfect Pendulum Clock if he had ſuch a one, and then have corrected the Time ſhewn by the Watch accordingly. However, ſuppoſing for a Moment his *Facts* to be genuine, I will deduce the *real Reſult* in the beſt Manner the Obſervations will admit, rejecting thoſe made while the Watch was in improper Poſitions, and thoſe during the Froſt, for the ſame Reaſons that Mr. *Maskelyne* lays no Streſs upon them, and for thoſe I have already ſtated. I ſhall therefore (purſuing his Idea of ſix Weeks) take it during the firſt tranquil ſix Weeks that it had, viz. from *July* the 6th, to *Auguſt* the 17th, in which Time it gained in all 11 Minutes, 50 Seconds, or $16\frac{9}{10}$ Seconds per Day which I will aſſume as the Rate of its going, or if Mr. *Maskelyne* pleaſes I will take the Average of his whole Time of Examination, from the 6th of *July* to the 3d of *January* and from the 9th of *January* to the 4th of *March*, which will come out at the Rate of $16\frac{8}{10}$ Seconds per Day faſt, and I ſay that according to either of thoſe Rates of going, the Watch kept the Longitude within the Limits of the Act of Queen *Anne*, during any Period of ſix Weeks that can be pointed out, excepting thoſe of extreme Cold, and improper Poſition which have already been explained. I do not trouble the Reader with the Calculations: If I aſſert an

Untruth, I ſhall hardly eſcape Contradiction.

There is another Inaccuracy, which tho' of leſs Conſequence, ought not to eſcape notice. One would naturally ſuppoſe when Mr. *Maskelyne* found the Watch went at this Rate of gaining on Mean Time, he would have been very exact in his Time of comparing it with his Clock; but on the contrary we find he was ſo irregular as to vary his Compariſons on ſucceeding Days from half an Hour to four Hours and 48 Minutes, and this not for a Time or two, but for one third of the whole Time he had it.

Mr. *Maskelyne* having ſhewn from the Reſult of his Calculation (which I have here proved to be falſe) that the Watch is not to be depended upon to determine the Longitude in a Voyage of ſix Weeks, then ſays, "these Conſiderations are ſufficient to explain the Motives which might have actuated Mr. *Harriſon*, as a Man of Prudence, in deſiring to ſend his Watch two Voyages to the Weſt Indies, upon his Idea that he ſhould be intitled to the large Rewards preſcribed in the Act of the 12th of Queen *Anne*, in Caſe his Watch kept Time within the Limits there mentioned, whether the Method itſelf was or could be rendered generally uſeful and practicable, or not;" this Inſinuation (*publiſhed under the Authority of the Commiſſioners of Longitude*) that I had contrived a Trial which I knew the Watch would fulfil, whilſt I was conſcious that it would not anſwer the general Purpoſes of the Act of Queen *Anne*, and conſequently that I had formed a villainous Scheme to rob the Publick of the Reward without really and effectually performing the Conditions, ſtrikes me as a Charge of ſo atrocious a Nature, that I think myſelf not only *juſtified* in publiſhing to the World what has been done with reſpect to Trials of the Merit of my Invention, but even *indiſpenſably obliged* ſo to do. I well know what I hazard thereby, and if the reſt of my Reward cannot be obtained on Principles of *National Faith* and *Publick Spirit*, I am contented to forego it, but I will not deſcend into the Grave loaded with that Diſhonour which my Enemies, availing themſelves of their Rank or Offices, have, in various Ways, attempted to throw upon me.

In the firſt Place I muſt remark, that the Trial referred to was not fixed *by me*, but by *an Act of Parliament* paſſed ſo long ago as the Year 1714, which (after veſting certain diſcretionary Powers in Commiſſioners to judge what Methods are likely to prove practicable, and authorizing them to iſſue ſmaller Sums of Money) goes on to fix the laſt grand Teſt of the Merit of any ſuch Invention, and enacts " that when a Ship, un-
" der the Appointment of the ſaid Commiſ-
" ſioners, ſhall thereby actually ſail from *Great*
" *Britain* to the *Weſt Indies* without loſing her
" Longitude beyond certain Limits, the In-
" ventor ſhall be intitled to certain Rewards."
Having from the Year 1726, employed myſelf

in adapting thoſe Principles which I had *at that Time* executed in a Pendulum Clock, to an Inſtrument or Time-Keeper ſo conſtructed as to endure the Motion of a Ship at Sea, and having made a Voyage to *Liſbon* and done ſundry other Things during a Courſe of Years, moſtly under the Direction of the Commiſſioners of Longitude, by way of preparatory Experiments, I thought the Invention ſufficiently perfect about the latter End of the Year 1760, to go upon the ultimate Trial, which I accordingly applied for. My Son, after being ſent to *Portſmouth* with the third Time-keeper (the fourth or Watch being to be ſent to him) was kept there five Months, waiting for Orders; which having by returning to *London* at Length obtained, he went to *Jamaica* in the *Deptford* Man of War, and returned in the *Merlin* Sloop of War, having fulfilled every Inſtruction of the Commiſſioners. It remained to compute from the Aſtronomical Obſervations made at *Portſmouth* and *Jamaica*, whether the Watch had or had not kept the Longitude within the preſcribed Limits; and as my Title to 20,000*l.* was to be determined thereby, I thought it but reaſonable that I ſhould name ſome Perſon to check the Computations, *which was refuſed.* The Commiſſioners appointed three Gentlemen for that Purpoſe, and on receiving their Report were pleaſed to declare *that the Watch had not kept its Longitude within the above men-*

*tioned Limits.** Thoroughly convinced of the contrary (for I had the ſame Materials they had to calculate from) I required a Copy of the Computations *which was alſo refuſed me*; nor could I ever obtain a Sight of them either officially or through private Favour, 'till three Years afterwards, when they were ordered to be laid before the Houſe of Commons; and it then appeared that two of the three Computations were abſolutely inconcluſive, proving nothing, and the third decided in my Favour. Further Proof of the Watch having ſucceeded in this Voyage may be found in the Journals of the Houſe of Commons, Vol. XXIX. P. 546, in the Evidence of *George Lewis Scott* Eſq; and Mr. *James Short*.

The Reader will eaſily believe I did not feel perfectly eaſy under this Treatment of an Invention to the perfecting of which (encouraged by the long continued Patronage of a *Graham*, a *Halley*, a *Folkes*, &c. &c.—— learned Friends to Society, and Publick Good, whoſe Minds were too enlarged, and Spirits too liberal to admit that *little* Jealouſy of inferior Artiſts, which ſince their

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* It may not be amiſs to take Notice here of an Objection that was raiſed by two of the Commiſſioners, both famous for their Knowledge in Aſtronomy; *viz.* That the Obſervations of equal Altitudes made at *Portſmouth*, could not be depended on, becauſe the equal Altitude Inſtrument had been removed from the Place of Obſervation in the Morning, to another Place to make the Afternoon Obſervations; from which it is plain that theſe great Aſtronomers did not underſtand either the Principles or Uſe of one of the moſt ſimple Inſtruments in Aſtronomy.

Death I have been expoſed to) I gloried in ſacrificing every Proſpect of Advantage from other Purſuits, and had willingly ſubmitted to lead a Life of Labour and Dependence. However 'twas too late to retreat; and I had only one Means of Succeſs left which was to follow the Commiſſioners in their own Way. Accordingly after many Difficulties (with a Relation of which I will not tire the Reader, as it is by no Means my Intention to meddle with any Subjects of Complaint, except ſuch as are material to the forming a right Judgment of the Trials made and propoſed) a ſecond Voyage to the *Weſt Indies* was agreed to in the latter End of the Year 1762, which Agreement was afterwards well nigh overſet by the Commiſſioners inſiſting on ſuch Aſtronomical Obſervations being previouſly made, as were next to impracticable in this Climate, and could be put into the Inſtructions for no other Reaſon that I could conceive, but to throw inſuperable Difficulties in my Way, as they were not at all material to the Determination of the Matter in Queſtion. However the Commiſſioners at Length gave up this Point on my Opinion of the Impracticability being confirmed by that of an Officer of the Navy diſtinguiſhed for his Abilities and Skill in Matters of Aſtronomy. To take away all Poſſibility (as I thought) of this Voyage being rendered fruitleſs like the laſt, I then deſired to have inſerted at the End of the Inſtructions ſome few Words to this Purpoſe, " that provided the Experiment " anſwered, the Commiſſioners preſent were of

Opinion

" Opinion I ſhould *without further Trouble* receive my Reward;" but my Son attending the Board with this Propoſition was told by Lord *Sandwich* at that Time Preſident, that it would be mere Tautology, for that their giving Inſtructions implyed the ſame Thing, and that if the Watch kept its Time within the Limits of the Act there could be no Doubt of my being entitled to and receiving the Reward, and nobody could take it from me. Upon the Faith of this, my Son went the Voyage to *Barbadoes*, in which the Watch kept its Time " conſiderably within the neareſt Limits of the " Act of Queen *Anne*," as certified, even by the Commiſſioners themſelves.

On the Succeſs of this Trial being known, and after having employed near forty Years of my Life on the Faith of an Act of Parliament, was a Doctrine broached to me (as I ſolemnly declare *for the firſt Time*) that the Commiſſioners were inveſted with a diſcretionary Power of ordering other Trials and the fulfilling of other Conditions than thoſe ſpecially annexed by Act of Parliament to the Reward;* An Expoſition of the Law, which I ever did and ever ſhall (until it is ſupported by legal Authority) totally reject and refuſe Obedience to; for I do maintain, that before paſſing the laſt Act of Parliament I had as full and perfect a *Right* to the Reward of 20,000*l.* as any Free-holder in *Britain* has to his Eſtate; and I never would have deſired nor ever will deſire any better Satisfaction than a judicial Determination of that Point; which however it was very ſoon thought proper to preclude me from, by a new Law, paſſed at the Inſtance of the Commiſſioners of Longitude, placing me *too certainly* under the Diſcretion of the Commiſſioners and totally changing the Terms on which the Reward was to be given me, enacting that I ſhould have half of it when I had diſcloſed the Principles and Conſtruction of the Machine, and aſſigned over for the Uſe of the Publick the laſt made Timekeeper, together with the three others which were not ſo perfect as the laſt; and the other half when I ſhould have made more Watches, *without determining how many,* and proved them to the Satisfaction of the Commiſſioners, *without defining the Mode of Trial.*

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* If this Interpretation of the Act was true, and the Commiſſioners had a general diſcretionary Power, where was the Reaſon or Uſe of ſpecifying *any Trial at all* in the original Act?

I frankly confeſs that from thenceforward I conſidered the ſecond Moiety of the Reward as loſt for ever. The firſt Moiety I obtained, tho' it was with great Difficulty, as the Act required me to explain my Invention upon Oath, and the Commiſſioners were pleaſed to put into that Oath, Words of an indeterminate and unlimited Meaning, and refuſed to explain them, or even permit me or my Son to aſk what was meant by them. We at length agreed to take it (finding we ſhould never get any Thing if we did not, ſuch was now the Power of the Commiſſioners) and they declared that themſelves and the Gentlemen appointed by them to whom we were to explain it, would be *upon Honour* not to diſcloſe it, that I might have an Opportunity of obtaining the Reward promiſed by foreign Powers; however, in leſs than a Month an Account of it appeared in the public News-Papers, ſigned by the Rev. Mr. *Ludlam*, one of the ſix Gentlemen named by the Commiſſioners to receive the Diſcovery, and therefore, I make no doubt, by Leave of the Board. Nor did they ſtop here, for they have ſince publiſhed all my Drawings without giving me the laſt Moiety of the Reward, or even paying me and my Son for our Time at the Rate of common Mechanicks; a Diſcouragement to the Improvement of Arts and Sciences, and an Inſtance of ſuch Cruelty and Injuſtice as I believe never exiſted in a learned and civilized Nation before.

I have already had Occaſion to mention, that at the Time I receiv'd the Certificate for the firſt Moiety of the Reward, the Watch was delivered up; it remained ſix Months locked up at the Admiralty, and was then removed to Greenwich, to be the Subject of thoſe Experiments concerning which I now trouble the Public. The other three Machines, were (by Order of the Commiſſioners) ſoon after demanded of me by Mr. *Maskelyne*. One of them which had been going more than thirty Years, was broke to Pieces *under his careful and ingenious management*, before it got out of my Houſe; and the other two were ſo far abuſed in the Carriage by Land to *Greenwich*, as to be rendered quite incorrect, and as far as I can learn, incapable of being repaired without having ſome eſſential Parts made anew. Thus periſhed the firſt Eſſays of this long wiſhed for Invention!

Unwilling however that the Public ſhould loſe the Benefit of the Diſcovery, or the Chance of further Improvement, I applied, by repeated Letters, to the Board, praying that the Watch might be lent to me (offering Security for it if required) for the Sake of employing other Workmen to make the different Parts by Model, with quicker Diſpatch, and in Order to determine by Experiments, whether ſome expenſive Parts of the Machinery might not be abridged or totally left out. Still have my Requeſts been refuſed, and of late they have alledged that they cannot keep their Engagements with Mr. *Kendall* if they were to lend me the Watch. What thoſe Engagements are may be ſeen below.* The new Act, as I have already obſerv'd, did not determine *how many* more Watches were to be made before I ſhould receive the other Moiety of the Reward: it was ſeven Months before I could get them to fix *how many*, and then they would neither agree to any Mode of Trial propoſed by me, nor propoſe any themſelves till *eleven Months* after that, *viz.* not till the 11th Day of *April* laſt, when (an Enquiry having been ſet on Foot in the Houſe of Commons) they were pleaſed to propoſe, that inſtead of the Length of a *Weſt-India* Voyage, which is about *ſix Weeks*, the Watches ſhould be placed with their very good Friend and Well-wiſher Mr. *Maſkelyne* for *ten months*, and then be ſent for two months on board a Ship in the *Downs*; and all this I am required to ſubmit to, without the leaſt Shadow of Aſſurance on their Part, that they will be ſatisfied with this Trial, let it anſwer ever ſo well, or that I ſhall thereby be brought at all the nearer receiving what is due to me, altho' (independent of making the Watches) it muſt neceſſarily employ one whole Year of mine or my Son's Time, in ſuperintending an Examination, which, after all, can only prove that I, who have made one Machine, can make another like it; and the Point of general Practicability, about which ſo much ſtir is *affected* to be made, would not be one Jot advanced beyond what it is at preſent.

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* The Board contracted with Mr. *Kendall* (one of the ſix Perſons to whom the Diſcovery was made) to make a Watch after the Model of mine. He was to be paid for every Thing before-hand, and to begin in a Twelvemonth after making the Bargain; he is to make Parts like Parts, but is not to be anſwerable for his Watch's going at all. My Timekeeper is now in his Poſſeſſion, tho' he is not yet ready to make Uſe of it: There are ſome Parts in the making of which the Model can be of little or no Uſe to him; I only deſired it for ſix or eight Months, and am confident he can have no Occaſion for it before that Time is expired: however I have offered to have it forth coming whenever Mr. *Kendall* declares that he wants it, therefore I apprehend their Engagements with Mr. *Kendall* afford no ſolid Reaſon for the Commiſſioners to refuſe lending it to me.

I cannot help begging the Reader will here allow me to add a Remark or two upon the general Practicability of my Invention;

as that is now ſaid to be the only Thing that was in Diſpute between the Commiſſioners and me, and that they only wanted to be ſatisfied as to this Point. In order to clear it up then, I will ſubmit to the Public to determine whether the general Uſe and Practicability of my Invention can, in the Nature of Things, be attacked, unleſs under one of theſe three following Heads:

1. That a Time-keeper, however perfect, is an inſufficient Means of aſcertaining the Longitude at Sea.

2. That ſuch Information has not been given as will enable other Workmen to make other Time-keepers of equal goodneſs with that which is certified to have kept the Longitude.

Or 3. That they will come to ſo enormous a Price as to be out of the Reach of Purchaſe.

From the Benefit of the firſt Objection (even if it was founded in Truth, which I utterly deny) the Commiſſioners have ſurely precluded both themſelves and the Nation, as with Reſpect to me, by their repeated Orders and Inſtructions, and after leading me on for near Half a Century, to employ my whole Time and make long Voyages for *perfecting* the Invention, they can never be permitted now to come and ſay *the Invention itſelf* is good for nothing. Should any one however continue to propagate ſuch an Opinion, I beg leave, in Contradiction to it, to offer that of Sir *Iſaac Newton,* and that of *Martin Folkes*, *Dr. Halley*, *Dr. Smith*, Mr *Graham*, and eight other Perſons of great Eminence, both publicly given to the Houſe of Commons and to be found in the Journals, *viz.* Sir *Iſaac*'s in Vol. 17, Page 677, and the others in Vol. 29, Page 547.

The ſecond Objection is flatly contradicted by Evidence lately before the Houſe of Commons, by which it appears that the Deſcription and original Drawings from which the Watch was made, as given in by me upon Oath, are printed and publiſhed; and that Mr. *Mudge* (the only one of the Watchmakers to whom the Diſcovery was made, who has been examined by the Houſe of Commons) declar'd he could make theſe Watches as well as I can. Moreover I am ready, on Condition of receiving the Remainder of what's due to me, upon Oath to give all manner of future Information and Inſtruction in my Power; and I hope it could never enter into any Man's Idea of general Practicability, that I ſhould actually teach every indifferent Workman in the Nation, and furniſh each of them with a Set of Tools for the Trial of his Ability, at my own Expence, before I could be entitled to the Reward.

With Regard to the third Objection, no Eſtimate of the future Expence can (from the Nature of the Subject) be grounded upon any Authority better than that of Opinion. The Price of common Watches, where each Part is made by a different Workman, bears no Proportion to what muſt neceſſarily be charged by any Man who was to make the whole with his own Hands: the ſame Reduction will naturally take place when a Number of Workmen are inſtructed to make the different Parts of theſe. My Opinion is, that they might in a very few Years be afforded for about £.100 a-piece, and if a Reduction of the Machinery can be effected (which I am ſtrongly inclined to think is the Caſe, but have not had an Opportunity of proving by Experiment for want of my Models) the Expence may be reduced to about 70 or 80 l.

By this Time I think the Reader may naturally exclaim, How can all theſe Things be? What can induce a Number of Noblemen, Stateſmen and Officers of the firſt Rank and moſt unblemiſhed Characters; what can induce the Preſident of the Royal Society, and the Profeſſors of the Univerſities (to each of whom his Majeſty has been moſt graciouſly pleaſed to order Payment of 15 l. per Day for every Board of Longitude they attend) and what can induce the Aſtronomer Royal, thus to diſcourage an Invention which they are ſpecially conſtituted to improve, protect, and ſupport? I might anſwer with Mr. *Maskelyne*, "that's none of my Buſineſs "to account for."—*The Facts are ſo*, and this public Relation of them is extorted from me, by a Conviction that no other Way is left me to obtain Juſtice, or ſo likely to prevent the Invention from periſhing. However, if it is expected of me, like Mr. *Maſkelyne*, to deliver an Opinion on this Point, I ſhall declare what I believe *very ſincerely*, that by far the greater Part of the Commiſſioners are perfectly innocent of the Treatment I have met with: moſt of them are Commiſſioners by Virtue of great Employments which engage their Time and Attention: A Board ſo conſtituted is continually changing; and this being a Matter of Science which to many may ſeem rather abſtruſe, it was very naturally left to the Management of a few of thoſe Members who ſtand in the moſt immediate Relation to Science, and whoſe Opinions, upon a Buſineſs of this Nature, the reſt of the Board had too much Modeſty to call in Queſtion. How well they have merited that Degree of Confidence is left to the impartial World to determine.

To return again to Mr. *Maskelyne*'s Account: He, as I think has been already ſhewn, having ſaid and done every Thing in his Power to the Diſhonour and Diſcouragement of my Invention, ſcruples not to ſum up his Opinion of it in the following Terms:

" That Mr. *Harriſon's* Watch cannot be " depended upon to keep the Longitude " within a Degree, in a *Weſt-India* Voyage " of ſix Weeks, nor to keep the Longitude " within Half a Degree for more than a " Fortnight, and then it muſt be kept in a " Place where the Thermometer is always " ſome Degrees above freezing: that, in " caſe the Cold amounts to freezing, the " Watch cannot be depended upon to keep

"the Longitude within Half a Degree for
"more than a few Days, and perhaps not
"ſo long, if the Cold be very intenſe:
"nevertheleſs, that it is a uſeful and valuable
"Invention, and in Conjunction with the
"Obſervations of the Diſtance of the Moon
"from the Sun and fixed Stars, may be
"of conſiderable Advantage to Navigation."

Having ſufficiently refuted the firſt Part of this Opinion already, it only remains for me to make ſuch Remarks on the Lunar Method of finding the Longitude, as this coupling of my Invention with it ſeems to call upon me for.

It is with Reluctance that I follow Mr. *Maskelyne* into a Subject in which I may ſeem, like him, to be actuated by a ſelfiſh Preference to my own Scheme; however, as I ſhall give my Reaſons for what I advance, I will not heſitate to ſubmit them to the Public. I beg to be underſtood as a warm and declared Friend to that and every other Mode which can be deviſed of aſcertaining the Longitude at Sea, ſo long as they keep within the Bounds of Reaſon and Probability. Here are now two Methods before the Public; Wou'd to God there were two Hundred! The Importance of the Object would warrant public Encouragement to them all; but, called upon to ſay ſomething on the Subject, I think it incumbent upon me to point out thoſe Limits beyond which its Utility cannot, from the Nature of the Thing, be extended.

The Method of finding the Longitude by the Moon, in which Mr. *Maskelyne* is in a pecuniary way intereſted, is this.—If the apparent Diſtance between the Sun and Moon, or between the Moon and ſome fix'd Star, at any certain Part of the Globe, was for every Hour of the Year known; and if a Navigator, when at Sea, could alſo, by Obſervations, aſcertain what is the apparent Diſtance, at the Place where he is, between the Sun and Moon, or between the Moon and a Star, and likewiſe their reſpective Altitudes; and if he could alſo, at the ſame Moment, aſcertain the Time of the Day, either by an immediate Obſervation of the Sun, or by a Watch which would keep Time pretty exactly from the laſt ſolar Obſervation; theſe Matters of Fact being given, the Difference of Longitude may from thence be calculated. I admit the Principle to be abſolutely true in Theory. The Lunar Tables, for which the Rewards have been given, are calculated to ſhew the Diſtance between the Sun and Moon, or Moon and Stars, at *Greenwich*; I admit the Practicability of making ſuch Tables; but with Regard to the other Requiſites, I beg Leave to obſerve that, for ſix Days in every Month, the Moon is too near the Sun for obſerving, conſequently, during thoſe Days, the Method falls *totally* to the Ground; that for about other thirteen Days in every Month, the Sun and Moon are at too great a Diſtance for obſerving them at the ſame Time, or are not at the ſame Time viſible; therefore, during thoſe 13 Days, we muſt depend upon Obſervations of the Moon and Stars, and upon a Watch to keep Time, from the laſt Solar Obſervation with ſufficient Exactneſs, which common Watches cannot be depended upon to do; well therefore might Mr. *Maskelyne* admit that my Invention would become of conſiderable Value, even if taken in Aid of the Lunar Tables. I leave the Reader to judge of the Practicability of making theſe Obſervations from what follows:

To aſcertain the Longitude by the Moon and a Star, requires a diſtinct Horizon to be ſeen in the Night, which is next to impoſſible, and if you have not an Horizon, the Altitude of neither Moon nor Star can be taken: It alſo requires (and this perhaps when a Ship is in a high Sea) the Diſtance of the Moon and Star, in order to come at which, the Image of one of them muſt be reflected through a ſilvered Glaſs, and the other ſeen through an unſilvered Part of the ſame Glaſs; and they muſt be brought into Conjunction in the Line that connects the ſilvered and unſilvered Parts, and this to an Exactneſs only true in Theory, for an Error of a Minute of a Degree committed in this Obſervation, will miſlead the Mariner Half a Degree in his Longitude; Now I call upon any Aſtronomers of Reputation publickly to declare, that they have, even at Land, and with the beſt Inſtruments *Europe* affords, been able to make this Obſervation of the Moon and a Star with *any thing like* the Preciſion required to determine the Longitude within the Limits required by the Act of the 12th of Queen *Anne* ; I know it cannot be done. Nay I further call upon any ſuch Aſtronomers to declare, whether even in Obſervations of the Diſtance between the Sun and Moon, two of them obſerving together have *generally ſpeaking* agreed in this Obſervation within a Minute of a Degree : I know that in general the Difference between the beſt Obſervers even at Land will be more, and as a farther Proof of this Aſſertion, I refer the Reader to the Note below :† And if

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† In the fifth Volume of M. DE LA CAILLE's Ephemerides, Page 31, he ſays, " that any Perſon would be in the wrong to ſuppoſe that the Longitude at Sea can be determined by the Moon, to a leſs Error than two Degrees, let the Method which is employed be never ſo perfect, let the Inſtruments, of the Sort now in uſe, be never ſo excellent, and let the Obſerver be the moſt able and accompliſhed. For if we examine, without prejudice, all the Circumſtances which enter into the Calculation and into the Obſervation of a Longitude at Sea, we ſhall be eaſily convinced, that it would be ridiculous to maintain, that the Sum of the inevitable Errors ſhould not amount to five Minutes of a Degree, that is, to two Degrees and a half of Longitude. *N. B.* M. DE LA CAILLE publiſhed this in the Year 1755, and is univerſally allowed to have been an excellent Obſerver, and made ſeveral Voyages by Sea, where he made Trials of this Method by the Moon.

Dr. HALLEY and Dr. BEVIS (as appeared to the Honourable Houſe of Commons upon an Examination of the latter) did, with an excellent HADLEY's Quadrant, rectified by Mr. HADLEY himſelf, and in his preſence, attempt to take the angular Diſtance of the Moon from ALDEBARAN, a Star if theſe Matters of Fact are ſtill doubted, I ſhall beg Leave to call upon Mr. *Maskelyne* and Mr. *Green* to declare how near they, with Admiral *Tyrrel* agreed in determining the Longitude by the Sun and Moon in their Voyage to *Barbadoes*; and alſo whether during that Voyage they ever did determine their Longitude by the Moon and Stars.—I know they did not, for they found the Obſervation too difficult, and indeed *it is only true in Theory*.

From the foregoing Premiſes I infer,

1ſt. That during ſix Days in every Month, no Obſervations can be made by this Method to aſcertain the Longitude at Sea.

2dly, That during 13 other Days in each Month, it is impracticable to aſcertain it by this Method with any Inſtruments hitherto contrived, or which the Nature of the Service to be performed ſeems to admit of

And 3dly, That during the remaining 11 Days in each Month, when the Sun and Moon may, if the Weather is clear be obſerved at the ſame Time, no Reliance can ſafely be placed upon the beſt Inſtruments in the Hand of the beſt Obſerver for aſcertaining the Longitude within the Limits of

the

Star of the firſt Magnitude; but with ſuch bad Succeſs (ſome of the Obſervations removing GREENWICH from itſelf almoſt as far as PARIS) that Dr. HALLEY ſeemed to be out of Hope of obtaining the Longitude by this Method.

the Act of Queen *Anne*; and conſequently, that how valuable ſoever the Lunar Tables may be for correcting a long dead Reckoning, and thereby telling us *whereabouts* we are, when we are not afraid of falling in with the Land, yet even during theſe 11 Days, they do not extend to the Security of Ships near the Shore.

This *Method* of aſcertaining the Longitude by the Moon has already coſt the Publick the Sum of 6,600*l.* at leaſt, and yet no proper Experiment has been made of it.

I ſhall not preſume to make any Reflections on the different Treatment the two Inventions have met with, nor will I take up more of the Reader's Time by a Detail of the very earneſt Attention paid by the *French* Government to this Object. If our Rivals in Commerce and Arts *ſhould* rob us of the Honour as well as the firſt Advantages of the Diſcovery, I hope it will be admitted that the Fault is not mine: And I likewiſe flatter myſelf that I have now furniſhed ſufficient Materials for the Juſtification of my Friends, and for ſhewing that the Cauſe which they from publick ſpirited Motives had the Goodneſs to eſpouſe, was not unworthy of their Patronage.

Red-Lion-Square,
June 23, 1767

JOHN HARRISON.

FINIS.